The Expected Shower of Leonids in 1897. By W. F. Denning.

The return of the *Leonids* in November next, though it may fairly be expected to afford a pretty abundant display, will occur in the presence of a gibbous Moon and thus lose much of the conspicuous character which it may quite possibly have exhibited in a dark sky. At midnight following November 14 the Moon will be twenty days old and therefore nearing her last quarter (November 17, $2^h\ 2^m$), but her light will be sufficiently strong to overpower many of the smaller meteors and to moderate the apparent brilliancy of the larger ones.

In November we shall be placed fully two years before a maximum return is expected, and the density of that part of the stream so far in front of its associated comet is not likely to be considerable, but we may get a shower of perhaps fifty or sixty *Leonids* per hour for one observer on the night following November 14. It must be remembered that the radiant does not rise on that date until 10^h15^m P.M. and passes the meridian at 6^h30^m on the following morning. Observations are not, therefore, likely to be very productive until after midnight in consequence of the unfavourable position of the radiant.

In 1831 (two years preceding the great American shower of 1833) a French naval officer, Captain Berard, commanding the brig, *Le Loiret*, reported to M. Arago that "on November 13, at four in the morning, the sky being perfectly cloudless and a copious dew falling, he saw a number of shooting stars and luminous meteors of great dimensions. During upwards of three hours more than two per minute were seen." Dr. Wright, of Ohio, U.S.A., also witnessed an abundant fall of meteors on the same morning. In 1864 (two years before the fine European display of 1866) a star-shower of considerable strength was observed from the s.s. *Ellora*, off Malta, on the morning of November 13, for according to the report of those on board "there was a brilliant display of meteors all through the watch."

Seeing, therefore, that marked showers presented themselves in 1831 and 1864, we appear justified in expecting a tolerably active display in 1897. By a comparison of the observations made of the *Leonids* in 1895 and 1896 (*Monthly Notices*, lvi. 255, and lvii. 277), it will be noticed that a marked increase occurred in the latter year. A relatively far greater increase may be expected in the coming November, though the richest part of the stream will probably envelope the earth during daylight in England on November 14 and pass unseen.

From a comparison of the "brilliant showers" which occurred in the years 1865, 1866, 1867, and 1868, Mr. B. V. Marsh, of Philadelphia, U.S.A., concluded that there probably existed three concentric meteor-groups. "The densest or middle part of the meteoric dream through which the earth passed in 1866 (observed in Europe) and 1867 (observed in America)

appears to be flanked on either side by lateral and somewhat less dense and wider meteoric currents, at a distance from the orbit of the main stream, which the earth crossed in about twelve hours on the mornings of 1865 November 13, and 1867 November 15." (*B.A. Report*, 1869, p. 302.)

Assuming the node to advance along the ecliptic at the average rate, shown by a comparison with the times of old observations, of fifty-seven minutes of arc, with reference to a mean moveable equinox, during one period of revolution, then the stream recurs six and a half hours later in an ordinary year, and seventeen and a half hours earlier in leap year. Thus it is only the half hour which progressively accumulates and with leap year dropped once in 3 centuries out of 4, as in 1700, 1800, and 1900, throws forward the date of the shower's recurrence by about 3 days in a century.*

The central meteoric group observed in 1866 and 1867 is not likely to be visible in England this year, as the earth will be involved with it at about noon on November 14, but the other two streams ought to furnish many meteors on the preceding and following mornings. If the motion of the node of the meteoric orbit has continued its previous rate since 1866 then the three groups, conjectured to exist by Mr. Marsh, ought to be centrally passed by the earth at the following times :—

Group		h.	Duration.		From obs. in
Preceding	Nov. 13	$9\frac{1}{4}$	12 hours	1865, Nov. 12,	America
Central	14	0	$4\frac{1}{2}$ „	1866–7, „ 13,	Europe and America
Following	14	15	$13\frac{1}{2}$ „	1867–8, „ 14,	China and America

The earth's longitude on November 14 at noon is 52° 25′.

With regard to this peculiarity of construction it must be confessed that it rests on somewhat slender evidence, especially in respect to the sparse intervals supposed to outlie the central group. The observations on which the theory depends were only those furnished by five showers at the last epochal return, and it is hoped that during the next seven years a large number of new data may be obtained, at places differing widely in longitude, to assist in the solution of this problem. Under more favourable circumstances the voids near the central current may be found less definite than supposed, but there can be no doubt of the shower's rich sustenance during a period of more than forty-two hours. In meteoric astronomy it is sometimes the unexpected which happens, so that, without placing implicit reliance on the exact times of occurrence of predicted phenomena, observers should watch carefully throughout those nights which offer the best general prospect of success.

In 1898 and 1901 there will be no moonlight to interfere with the brilliant aspect of the shower, in 1900 the Moon will be half illuminated, and in 1899 and 1902 our satellite will be near the full. In England we should probably have witnessed the most brilliant

* See an interesting letter and diagram, explanatory of this part of the subject, in *Nature*, 1896 December 24, by Professor A. S. Herschel.

display of all in 1899, as it is due at about 1 A.M. on November 15, but the flood of moonlight over the sky will operate most unfavourably upon the visible nature of the phenomenon. In 1900 the circumstances are more to our advantage, and an unusually fine exhibition seems likely to occur just before sunrise on November 15, but the sky will be rather light in the presence of a moon at her last quarter.

One of the features which ought to be ascertained at every return is the time of apparent maximum of the shower. In deducing this the height of the radiant ought perhaps to be considered, for a radiant near the zenith will apparently yield more meteors than a stronger system with its radiant at a low altitude. In fact, the visible strength of a radiant depends largely, as pointed out by Lieut.-Colonel Tupman some years ago, upon its zenithal distance. The hourly number of meteors, for a radiant at the zenith, may be computed by multiplying the number actually counted in an hour by the secant of the zenith distance of the radiant. The number so derived will give the number of meteors which would have diverged from the radiant had it occupied a place in the zenith.

Another circumstance affecting the hourly number of *Leonids*, but chiefly during a comparatively weak display, is that there are many other showers of streak-leaving meteors in and surrounding *Leo* at the middle of November. Some observers count all the meteors shooting from the general direction of *Leo* as *Leonids*, and thus the actual number of the latter is exaggerated. Allowance should always be made for these minor streams. A list of their radiants appears in *Popular Astronomy*, 1894 March, and *The Observatory*, 1897 January. The principal of them are situated near δ and ι *Cancri*, μ, and ξ *Ursæ Majoris*, and π, λ, τ and β *Leonis*.

The real paths of several interesting *Leonids* and *Cancrids* were determined, in 1896 November, as the result of simultaneous observations at various stations. If a few additional observers co-operated to gather similar materials during the ensuing return a large number of meteors might be secured, and not only *Leonids* but members of the numerous contemporary showers such as *Taurids*, *Perseids*, *Aurigids*, *Cancrids*, *Ursids*, &c., might have their heights, radiants, &c., accurately attributed. It is proposed to make a special effort in this direction and to arrange for systematic watching during several hours on the mornings of November 14, 15, and 16 next. If observers in the N. of England looked to South, while those in the S. of England looked to North, and those in the S.E. and S.W. districts directed their observation to the north-west and north-east respectively, and recorded the apparent flights of the most conspicuous meteors which appeared, a plentiful collection of doubly observed objects would sure to be discovered amongst the observations.

Bristol: 1897 *June* 7.

Ephemeris for Physical Observations of the Moon, 1897 September to 1898 April. By A. Marth.

Greenwich Noon.	Selenographical Colong. of the Sun.	Selenographical Lat. of the Sun.	Geocentric Libration Sel. Long. of the Earth.	Geocentric Libration Lat. of the Earth.	Combined Amount.	Direction.
1897.	°	°	°	°	°	°
Sept. 4	4·80	−0·93	+2·45	+4·84	5·42	333·2
5	17·00	0·95	3·29	3·56	4·85	317·3
6	29·19	0·98	3·98	2·09	4·49	297·8
7	41·38	1·00	4·49	+0·51	4·52	276·5
8	53·56	1·02	4·82	−1·07	4·94	257·5
9	65·74	1·05	4·98	2·57	5·60	242·7
10	77·91	1·07	+4·95	3·91	6·30	231·6
11	90·08	1·09	4·71	5·02	6·88	223·1
12	102·25	1·11	4·26	5·86	7·24	215·9
13	114·42	−1·13	3·59	6·40	7·33	209·2
14	126·60	1·15	2·71	6·63	7·16	202·1
15	138·78	1·17	1·65	6·56	6·77	194·1
16	150·97	1·19	+0·45	−6·21	6·23	184·1
17	163·16	1·20	−0·85	5·59	5·66	171·4
18	175·35	1·22	2·16	4·73	5·20	155·5
19	187·55	1·23	3·42	3·66	5·01	137·0
20	199·75	1·25	4·53	2·42	5·13	118·1
21	211·96	1·26	5·41	−1·03	5·50	100·9
22	224·17	−1·27	−5·97	+0·43	5·98	85·9
Oct. 2	346·36	−1·39	+4·36	+3·63	5·67	309·9
3	358·55	1·41	5·12	2·20	5·57	293·3
4	10·74	1·42	5·60	+0·66	5·63	276·7
5	22·92	1·43	5·81	−0·89	5·88	261·3
6	35·09	1·44	5·81	2·36	6·26	247·9
7	47·26	1·46	+5·60	−3·68	6·74	236·6
8	59·42	1·47	5·23	4·79	7·09	227·4
9	71·58	1·48	4·70	5·65	7·34	219·6
10	83·74	1·49	4·01	6·22	7·40	212·6
11	95·90	−1·49	3·16	6·50	7·22	205·8
12	108·05	1·50	2·15	6·48	6·83	198·3
13	120·21	1·51	+1·01	−6·17	6·25	189·2
14	132·37	1·51	−0·26	5·59	5·59	177·4
15	144·54	1·52	1·60	4·77	5·03	161·5
16	156·71	1·52	2·96	3·75	4·78	141·8